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OVERVIEW

NOAA - POLAR SATELLITE SYSTEM

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1.0 INTRODUCTION

The United States has conducted meteorological data collection from space since the successful launch of the Television Infrared Observation Satellite (TIROS-1) on 1 April 1960. It has maintained a polar orbiting environmental satellite system in continuous operation from the first launch until the present time. Collected environmental data are distributed to the U.S. National Weather Service, other Government agencies, researchers, and other data users. These data provide for weather forecasting, severe storm detection and tracking, wind measurements, sea surface thermal conditions, frost, sea surface ice conditions, and precipitation estimates. The civilian polar satellite system also contributes to the international World Weather Watch program of the World Meteorological Organization (WMO). It provides polar satellite data, without cost, on a real-time broadcast basis, and by distribution through the teletype network of the WMO Global Telecommunications System.

1.1 Purpose

The purpose of this document is to provide on overview of the basic elements of the polar orbiting meteorological satellite system operated by the National Oceanic and Atmospheric Administration (NOAA), of the U.S. Department of Commerce (DoC). It provides a level of detail sufficient to introduce the space and ground segments of the polar satellite system and the manner in which the system is operated.

1.2 Organization

Section 1 of this document provides background information on the polar system presently in operation. Section 2 provides an overview of the spacecraft instrumentation and payload communication devices. A description of the spacecraft bus of the Advanced TIROS-N (ATN) satellite of the Series H-J is contained in Section 3. Section 4 outlines the changes to the current Series H-J spacecraft by the follow-on Series K-N'. An overview description of the polar satellite ground system is povided in Section 5. Section 6 contains an overview of the NOAA polar orbiting satellite system operation. Section 7 provides the reader with information regarding the flow of data from the satellite instruments to ground stations to the end data users.

1.3 Background

The National Environmental Satellite, Data, and Information Service (NESDIS) of NOAA is responsible for operating the U.S. civil environmental satellite program. As part of this responsibility, NESDIS manages the NOAA polar orbiting satellite system. This responsibility extends from the command and control of, and data acquisition from the satellites, the processing of mission data, product distribution, and archival storage. NESDIS supports these responsibilities through the capabilities of the polar satellite ground system. The ground system comprises the Satellite Operations Control Center (SOCC) and Central Environmental Satellite Computer Center (CEMSCS) located in Suitland, Maryland, and the NOAA Command and Data Acquisition (CDA) stations at Fairbanks, Alaska (FBKS) and Wallops Station, Virginia (WAL).

-Command and data acquisition control of the polar orbiting TIROS satellites is conducted from the SOCC, through communications links with the ground system facilities -at the CDA stations. These functions are performed when orbiting satellites are in line of sight of the CDA station's command transmitting and data receiving antennas.

Polar orbiting satellite operations are conducted on a schedule driven, automated basis, with capability for operator manual intervention where circumstances dictate. Collection of instrument data and their transmission (downlink) to ground facilities is under the control of a Stored Command Table (SCT) loaded daily into memory of the on-board redundant Central Processing Units (CPU) of the spacecraft. In conjunction with generation of the SCT table, a CDA station Command Level Schedule is created to configure the ground system in consonance with spacecraft activities. The automated features-of system operation are supported by the Polar Acquisition and Control Subsystem (PACS), a computer based realtime control system. The PACS performs the processing and display of spacecraft health and safety telemetry for operator monitoring, and generates commands for control of spacecraft subsystems. A feature of the PACS is a schedule generation function conducted in non-realtime to produce time tagged schedules for automated operation of spacecraft subsystems and ground system equipment.

TIROS spacecraft are launched into one of two circular, sun synchronous, near-polar orbits. The 450-nmi morning orbit with a nominal equator crossing time of 9:30 a.m., or a 470-nmi afternoon orbit with a nominal 1:30 p.m. equator crossing, are sun synchronous in that the satellites cross the equator at the same local time each orbit. This provides consistent illumination of the area observed. The orbital period is nominally 102 minutes, permitting just over 14 complete earth orbits daily. As the Earth rotates under each orbit, satellite instruments view a different portion of the Earth's surface and atmosphere, providing global observations,

2.0 POLAR SPACECRAFT OVERVIEW

The polar orbiting meteorological satellite system at present is orbiting the fourth generation NOAA H-J series of spacecraft with a design life of greater than two years. A follow-on series, NOAA K-N', is under construction, with the first launch planned for 1995.

Polar satellite launches are scheduled when necessary to replace in-orbit failures of spacecraft bus or instrument payload functions. The current operational configuration of the TIROS satellite constellation has one AM satellite and one PM satellite in "Operational" status, while the satellite with limited or degraded functions being replaced is operated and maintained in "Standby" status. Two satellites are maintained in Standby with any other partially functioning spacecraft in the constellation turned off to a "Deactivated" status.

2.1 Instrumentation

The polar orbiters provide a stable space platform for an inventory of data collection instruments and unrelated, autonomous, communications devices. Each spacecraft carries a baseline of operational meteorological instruments, and may also carry developmental instruments on what is considered a "Mission of Opportunity" basis.

2.1.1 Baseline Instruments

Instruments which are included in the payload of every TIROS spacecraft launched, are the following:

Advanced Very High Resolution Radiometer (AVHRR): The AVHRR is a scanning radiation detection imager with five detectors in the visible and infrared (IR) bands. The visible and the low frequency IR channel observe vegetation, clouds, lakes, shorelines, snow, and ice. The other three IR channels detect heat radiation from and hence the temperature of land, water, sea surfaces and the clouds above them..

TIROS Operational Vertical Sounder (TOVS): The TOVS consists of three instruments which measure radiant energy at various altitudes to determine the Earth's temperature profile from the surface to the upper stratosphere (50 km). The three instruments of the TOVS are:

> Stratospheric Sounding Unit (SSU): Temperature measurements in the upper stratosphere are derived from radiance measurements made in three channels using pressure modulated gas (CO,) to accomplish selective band pass filtering of the sampled radiance. The gas is contained in three cells located in the optical path of the three channels.
>
> High Resolution Infrared Radiation Sounder (HIRS/2): Radiance measurements are taken in 20 spectral regions of the IR band from the Earth's surface to an altitude of about 40 km.
>
> Microwave Sounding Unit (MSU): Temperature measurements are made by radiometric detection of four frequency channels of microwave energy. Measurements are made by comparing the incoming signals from the troposphere (20 km) with an ambient temperature reference load.

Space Environment Monitor (SEM): The SEM is a multichannel, charged-particle spectrometer that measures the population of the Earth's radiation belts and the particle precipitation phenomena resulting from solar activity.

2.1.2 Mission of Opportunity Instruments

In addition to the baseline instruments that are upgraded over time as sensor technology evolves, the TIROS spacecraft provides for inclusion of developmental instruments in its payload. Operation of these instruments is also under schedule driven, automated control.

Examples of instruments included in this category are:

Solar Backscatter-Ultraviolet Spectral Radiometer (SBUV): The SBUV is a spectrally scanning ultraviolet radiometer to measure solar irradiance and scene radiance (backscattered solar radiance) in the 160 to 400 nanometers ultraviolet spectral range. From these measurements the total ozone concentration in the atmosphere and the vertical distribution of atmospheric ozone is determined.

Earth Radiation Budget Exoeriment (ERBE): The ERBE is a wide field of view, non-scanning radiometer, and a narrow field of view scanning radiometer, It is an experimental prototype to measure the Earth radiation budget components. It has a resolution of 200 to.250 km from which monthly averages of the Earth's radiation components are derived.

2.3 Baseline Communications Devices

Also contained in the baseline payload are autonomous communications devices that do not require ground system control, including:

ARGOS/Data Collection Svstem (DCS): Data collection platforms (buoys, free floating balloons, remote weather stations) of the DCS system collect relevant meteorological data and transmit them to the satellite. The on-board DCS receives the incoming signals, time tags them, and retransmits them to a NOAA CDA station under control of the Data Acquisition and Processor Subsystem, independent of, and external to, the PACS. DCS data is also contained in the spacecraft TIP low rate telemetry data stream.

Search and Rescue (SAR): The SAR consists of an SAR Repeater and a SAR Memory. The SAR receives distress signals from emergency beacons on the 121.5 Mhz, 243 Mhz, 406 Mhz international distress frequencies, and retransmits them at 1544.5 Mhz. The 406 Mhz emergency beacon signals are also processed and stored in memory and retransmitted directly to world wide Search and Rescue "Local User Terminal" ground stations from a continuous memory dump.

3.0 SPACECRAFT DESCRIPTION: ATN SERIES H-J

TIROS is a 3-axis body stabilized spacecraft 13.7 ft. in length and 6.2 ft. in width, manufactured by Martin Marietta Astrospace (formerly G.E. Astrospace) at East Windsor, NJ. It has a lift-off weight of 3,775 lb, including the solid rocket Apogee Kick Motor, and a 2,288 lb in-orbit weight.

It is launched from the Western Space and Missile Center at Vandenberg Air Force Base, CA, by a General Dynamics Corp. Atlas E series launch vehicle.

At launch, guidance and control of the Atlas launch vehicle is performed by the Atlas Guidance and Navigation System until spacecraft separation. Prior to launch, a launch software package is loaded into the spacecraft on-board processor to control the spacecraft Ascent **Guidance** System

(AGS) in the "boost mode" from lift-off to spacecraft separation from the Atlas booster rocket. The AGS navigates until separation and subsequently navigates, guides, and controls the spacecraft through Apogee Kick Motor burn and orbit injection to transition to "orbit mode" operations at about 34 minutes from lift-off.

3.1 Data Handling Subsystem

The spacecraft Data Handling Subsystem processes and formats all instrument payload and housekeeping telemetry data. The following components are provided for data handling:

Five Dual Transport Digital Tape Recorders (DTR): Each recorder consists of two tape transports with a common set of electronics. This provides a total of ten tapes for recording, and five recorders which can be operated simultaneously in either the record or playback mode. Each tape has a maximum capacity to record 11.5 minutes of 1 km. data, and 115 minutes of reduced resolution 4 km. data.

Dual TIROS Information Processor (TIP): At launch, during the ascent phase of operation, the TIP generates 16.64 kbps boost mode telemetry, consisting of 80 CPU inputs of ascent guidance information, 16 analog input channels and 16 8 bit words of boost mode analog telemetry. In orbit mode, the TIP formats all housekeeping data and all science data from all payload instruments except the AVHRR, into an 8.32 kbs TIP data stream.

Manipulated Information Rate Processor (MIRP): The MIRP processes and formats all data from the AVHRR which outputs a 665.4 kbps data stream of 1 km resolution imager data. The MIRP produces four output formats simultaneously from the AVHRR data, as follows:

(a) High resolution (1 km) AVHRR all channel video for recording as Local Area Coverage (LAC) in which the TIP data is imbedded.

(b) Realtime AVHRR all channel high resolution data broadcast as the High Resolution Picture Transmission (HRPT), in which the TIP data is imbedded.

(c) Realtime medium resolution two AVHRR channel video for Automatic Picture Transmission broadcast.

(d) AVHRR all channel, medium resolution (4 km) video for recording as Global Area Coverage (GAC), in which the TIP data is imbedded.

Cross Strap Unit (XSU): The XSU switches data streams between data handling components such as the DTRs and to four S-Band Transmitters of the Communications Subsystkm.

3.2 Communications Subsystem

The Communications Subsystem consists of the S-Band and VHF antennas, receivers, and transmitters required for mission operation. The functional requirements of the Communications Subsystem are mission phase dependent.

3.2.1 Launch Phase

Launch Phase is defined as the time from lift-off until mission mode is entered at about 34 minutes after lift-off, at which time the solar array and all antennas have been deployed. From lift-off through the powered flight the Communications Subsystem is in "boost mode" of operation. During boost mode, transmission of 16.64 kbps boost mode TIP data is over the 1702.5 Mhz Mid S-Band channel through an S-Band omnidirectional antenna. After booster separation, the 16.64 Mhz TIP data is also transmitted on the USAF Satellite Control Network 2247.5 Mhz S-Band emergency telemetry channel. "Orbit mode" operations begin at "handover" of spacecraft attitude control from the Ascent Guidance System to the spacecraft Attitude Determination and Control Subsystem. At handover, the SOCC operations staff becomes responsible for commanding the satellite.

3.2.2 Mission Phase

At handover to Mission Phase with the Communications Subsystem in orbit mode of operations, a 21 day Activation and Evaluation phase is entered. During this phase a launch support engineering team, operating from the SOCC Launch Control Room, conduct tests during which the spacecraft bus subsystems and payload instruments are activated and performance data collected. At the end of the 2 1 day period, the on-going meteorological data collection mission is entered under operational control of the NOAA SOCC and CDA station staffs.

The Communications Subsystem during continuous mission operations provides the following capabilities:

- Broadcast of High Resolution Picture Transmission (HRPT) at Low S-Band 1698 Mhz (AM Satellites) or at High S-Band at 1707 Mhz (PM Satellites).

- Reception and demodulation of digital commands in USAF Space Ground Link System (SGLS) format, transmitted at 148.56 Mhz VHF frequency.

- Transmission at 1702.5 Mhz, and 1698 MHZ (PM Satellites) or 1707 Mhz (AM Satellites) of:

  - Global Area Coverage (GAC) data; a reduced resolution (4 km) data stream produced by the MIRP, plus the housekeeping and all other low data rate instrument data contained in the TIP data stream, recorded on a DTR each orbit to provide global coverage. The storage capacity of the

DTRs requires the reduction of the 1 km AVHRR output to 4 km resolution. Record time is 115 minutes, playback time is 2.87 minutes at 2.66 Mbps or 5.75 minutes at 1.33 Mbps.

Local Area Coverage (LAC) data; 11.5 minutes of the AVHRR full resolution 1 km data, providing limited area coverage in response to users' requests. Record time is 11.5 minutes, playback time is 2.87 minutes.

Stored TIP (STIP) data; global recording of all satellite housekeeping and low data rate instrument data (TIP) played back at 332.7 kbps in 5.75 minutes.

- Broadcast of the serial bit stream TIP data at the VHF Beacon Transmitter (BTX) frequency of 136.77 Mhz (AM orbit) or 137.77 Mhz (PM orbit). TIP can be commanded to CPU Memory Dump Mode, Single Point Analog Dwell Mode, and Orbit Mode of operation. TIP data is routed to the MIRP for multiplexing in the HRPT, GAC, and LAC signals.
- Broadcast of 2400 baud Automatic Picture Transmission (APT) data at VHF Real-Time Transmitter frequency of 137.50 Mhz or 137.62 Mhz. The APT broadcast provides facsimile format imagery consisting of the visible and one IR channel of data during daylight hours, and is switched at the day/night terminator to provide two channels of IR imagery during periods of darkness.

3.3 Command and Control Subsystem (C&CS)

The C&CS basically comprises two CPUs, miniaturized general purpose data processors, a Controls Interface Unit (CIU) to generate and distribute control, clock, timing and data signals, and software. Included in the software is a Real-Time Processor module which performs initial processing on commands to provide command verification and error messages, and perform memory load functions. The software also contains a Command Processor module which does the actual decoding and execution of real-time, internal, and stored CPU decoded commands, providing verification of command completion or an error message if not completed.

During the course of normal spacecraft operations it is periodically necessary to uplink various load files to the C&CS memory. These loads are produced and distributed by the PACS, including:

- Daily Stored Command Table loads
- Weekly Ephemeris Table loads
- Macro Command loads
- On-Board Processor Software loads
- Power-On Processor Software loads
- Telemetry Table loads
- Power Maintenance Software Table loads.

3.4 Attitude Determination and Control Subsystem (ADACS)

The ADACS is an autonomous, active control subsystem which provides 3-axis attitude determination and control of.the spacecraft. It uses Reaction Wheel Assemblies (RWAs) with magnetic unloading and a reference system derived from an infrared horizon scanning Earth Sensor Assembly, with Sun Sensor Assembly updates. The ADACS contains an Inertial 'Measuring Unit with four strapdown integrating rate gyros to provide incremental digital inertial attitude signals to the satellite's CPU. Geometric Data Software provides for 0.5 second computations in the CPU for attitude control.

Ephemeris tables are stored in the CPU and are used for data inputs to the attitude control computations. The Ephemeris Updating Service software of the ADACS requires weekly ephemeris table updates based upon ground based radar tracking data provided to the SOCC by the USAF Space Data Operations Center (SPADOC). The ephemeris table updates are created in the SOCC by the Navigation function of the PACS which produces, verifies, and distributes a pair of Ephemeris Table Uplink Files for transmission to the spacecraft.

3.5 Electrical Power System

Power is generated by an oriented solar array to automatically track the sun under control of CPU software. Comparison between a computed sun position and the position of the array provides error signals to drive the array at one revolution per orbit. Voltage regulation, battery charge and discharge control, fault detection, and backup switching are all automatic, requiring infrequent intervention by ground command. The ground system does generate, verify, distribute, and uplink power-on processor loads and power system maintenance loads as required.

3.6 Reaction Control Subsystem

The Reaction Control Subsystem consists of hydrazine monopropellant thrusters used only in ascent and orbit adjust phases of the niission and then are deactivated, and nitrogen gas thrusters as RWA momentum desaturation backup in the nominal ADACS mode.

3.7 Thermal Control Subsystem

The Thermal Control Subsystem provides fully automatic control of heaters and louvers to maintain temperatures within specification limits, without ground control.

4.0 SPACECRAFT DESCRIPTION: SERIES K-N'

The operational mission requirements for ATN K-N' are essentially identical to those of the preceding ATN H-J missions. The complement of baseline instruments will be modified to replace the MSU and SSU with the Advanced Microwave Sounding Unit (AMSU). This will require an addition to the Data Handling Subsystem to incorporate a new AMSU Information

Processor (AIP) with a 16.64 kbps data rate, and a new Stored AIP (SAIP) data format. The C&CS will be modified to replace the current plain text command system with command encryption capability, and the current USAF 1 kbps Space Ground Link System (SGLS) command data format will be replaced with the Goddard Space Tracking and Data Network (GSTDN) 2 kbps command format. The Communications subsystem will be modified to replace the current 146.5 Mhz VHF command link with a 2026 Mhz S-band link.

5.0 GROUND SEGMENT DESCRIPTION

SOCC, from where all polar ground segment activities are conducted, is located in a secure area on the second floor of Federal Building 4 (FB-4) at Suitland, MD. Within the secure confines are the SOCC Operations area, SOCC Equipment Room, and a Launch Control Room for support of polar satellite and Geostationary Operational Environmental Satellite (GOES) launches. Adjacent to the SOCC are Scheduler offices where polar system schedules are produced.

CEMSCS, also located in FB-4, preprocesses raw satellite data forwarded from the SOCC, to perform quality control and data conditioning to meet NOAA National Weather Service (NWS), Department of Defense (DoD), other Government agencies, researchers, and other data user requirements. The linkages between polar ground segment facilities are illustrated in Figure 1.

5.1 SOCC Description

At SOCC, the PACS uses three DEC VAX 8550 computers in a VAXcluster, sharing 11.2 Gbytes of disk storage. These computers, designated Telemetry and Command Subsystem (TCS 1-3), serve as the central computing facility for SOCC operations. They perform the realtime functions of telemetry processing including decommutation, limit sensing, trend data generation, and telemetry history archiving. The TCS performs command generation and formatting in response to Spacecraft Controller workstation keyboard requests. The TCS also performs textual and graphics display generation for distribution through a dual rail Ethernet network to 17 VAXStation 3 100 workstations and associated printing devices.

The TCS computers also support the non-realtime functions of reports generation, Scheduling, Navigation, Trends plotting and analysis, and the Test and Training Subsystem (TTS) spacecraft simulator.

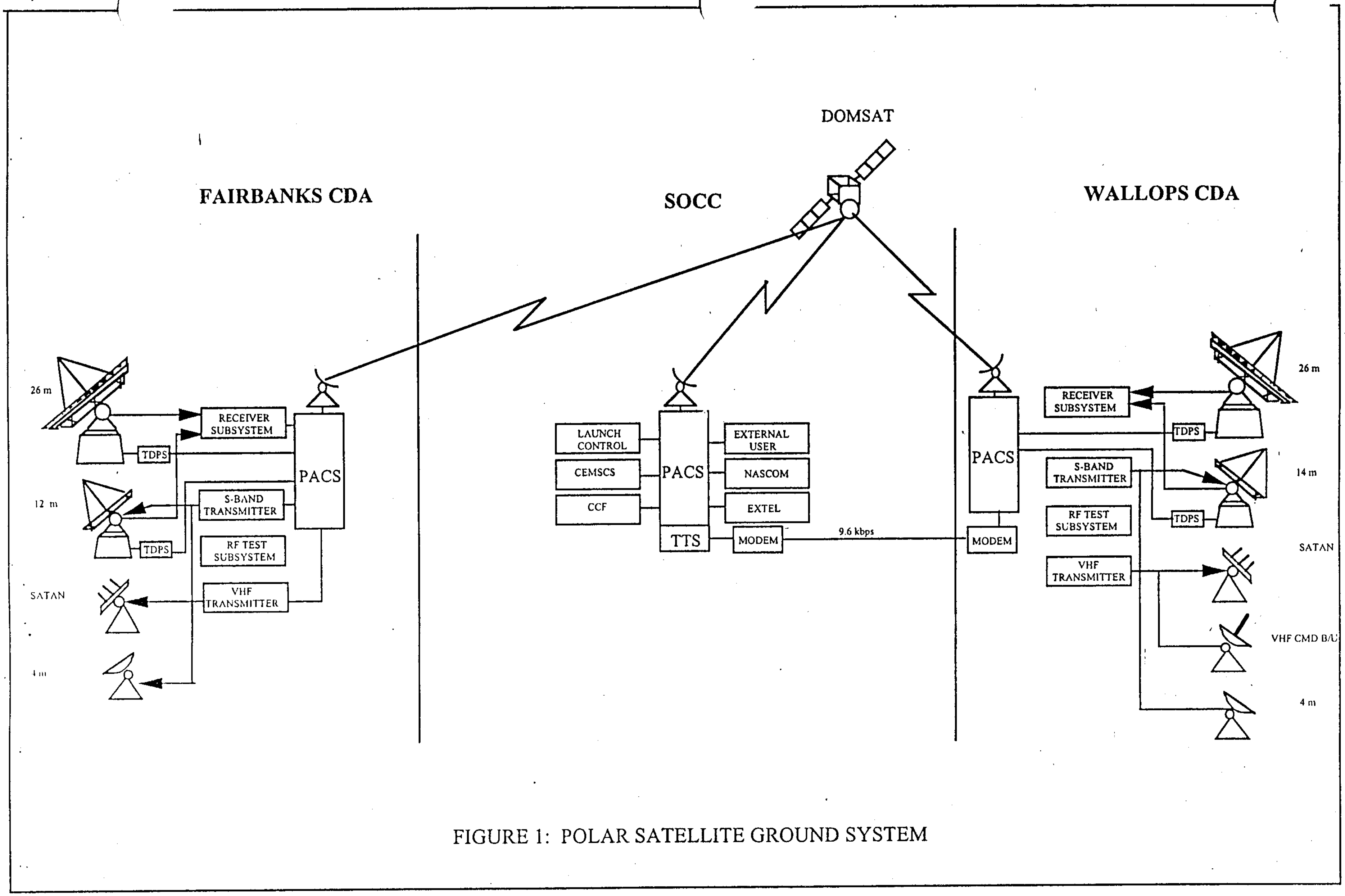

FIGURE 1: POLAR SATELLITE GROUND SYSTEM

Through Vitalink TransLAN III bridge devices, two sets of redundant DEC MicroVAX IV communications controllers. are interconnected by redundant 56 kbps links to each of the two CDA stations. The SOCC Ethernet is extended via Translans and redundant 56 kbps satellite circuits to the NOAA CDA stations to create an integrated Wide Area Network (WAN) as shown in Figure 2.

5.2 CDA Station Description

The ground systems at the FBKS and WAL CDA stations for polar operations are identical in function and consist of the following subsystems:

Antenna Subsystem: The. primary receiving antenna at the CDA stations is the 26 meter VHF/S-band, prime focus, parabolic, tracking antenna. Associated with the antenna is a Tracking Data Processor Subsystem (TDPS) which provides program tracking or auto tracking based upon phase error signals generated by the monopulse feed and autotrack Multi-Function Receivers (MFRs). The TDPS is updated with Inter-Range Vectors (IRVs) generated by the Scheduler, based upon a User Ephemeris File (UEF) produced by the NOAA Central Computing Facility (CCF). The UEF is created for each satellite from radar tracking data supplied daily by the USAF SPADOC.

The antenna subsystem also includes a Satellite Tracking Antenna (SATAN) VHF command transmitting antenna which is slaved to a tracking antenna for positioning data to track orbiting NOAA H-J satellites.

A 14.2 m. VHF/S-band receive, S-band transmit, prime focus parabolic auto track antenna is the primary S-band command antenna at WAL. It also has an associated TDPS which operates as described for the 26 m. antenna.

A 12 m. VHF/S-band receive, prime focus parabolic antenna, with an associated TDPS is the secondary receive antenna at FBKS.

A 6 m. S-band transmit antenna is the primary S-band command antenna at FBKS.

A 4 m. parabolic steerable antenna provides S-band command backup at both WAL and FBKS.

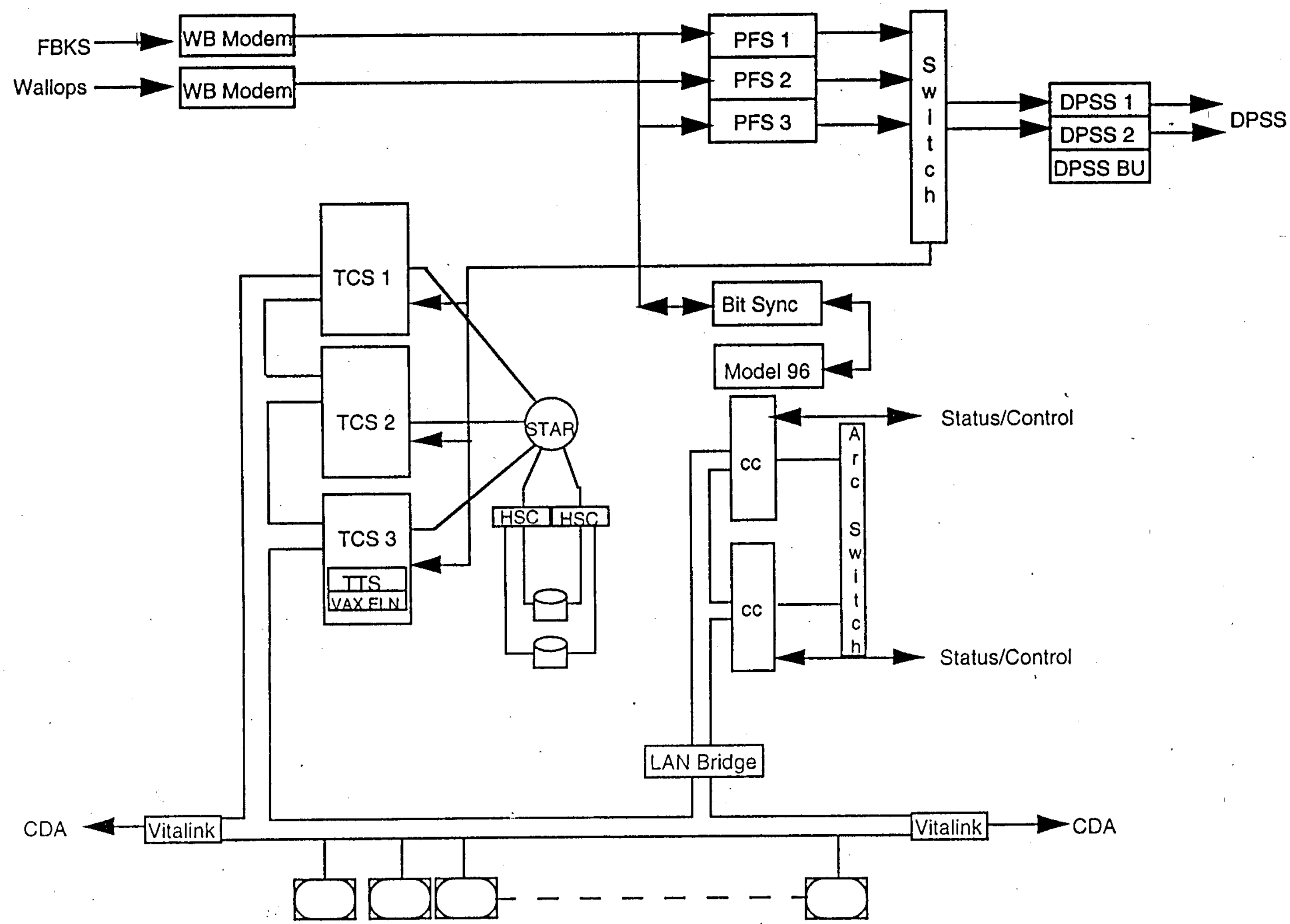

FIGURE 2: SATELLITE OPERATIONS CONTROL CENTER (SOCC)

- RF Subsystem: The RF Subsystems consists of the front end preamplifiers, up and down convertors to produce the Intermediate Frequency (IF) inputs to the MFR's. IF signals generated are routed through a computer controllable Intermediate Frequency Distribution Subsystem (IFDS) to the MFRs. Eight MFRs are available at each CDA stations to demodulate received signals to baseband for input to the ground system data handling equipment and to generate error signals for autotracking.

- Command Transmission: Each CDA station will transmit uplink commands for NOAA H-J satellites by means of redundant command encoders, redundant VHF transmitters, using the VHF SATAN antenna. Each CDA station will transmit uplink encrypted commands for NOAA K-N' satellites by means of redundant command encryption equipment, command generators, and S-band transmitters, using the 14 m. (WAL) aiid 6 m. (FBKS) primary S-band command antennas. A 4 m. S-band backup antenna is available at each station and will be used for simultaneous acquisition of NOAA K-N' satellites.

- Data Handling: Each CDA station is equipped with six PACS Bit Synchronizers (PBS) to recover clock and data from received signals. The bit synchronizers output timing and data for input to:

  Six PACS Frame Synchronizers (PFS) for input to the CDA PACS computers. The PFSs synchronizes and develops data quality information on received signals.

  Two Metrum wideband data buffers'(WDB) through PACS computer controlled 6: 12 Matrix switches

  A 1.33 Mbps Wideband Data Modem for satellite transmission to the SOCC

- PACS Computers: The PACS at the FBKS and WAL CDA stations use a single DEC VAX 8550 TCS computer and redundant DEC MicroVAX IV communications controllers. The CDA TCS is identical in function to the SOCC TCS and provides backup in the event of a SOCC or SOCC/CDA communications failure. It is capable of running the same software programs as the SOCC but does not have the mass storage capabilities of the SOCC for history and trends data. In normal operations the CDA TCS runs in synchronization with the SOCC TCS whereby, in the event of SOCC disruption, it can immediately take over system operation. The CDA PACS also performs the same command and telemetry processing functions as the SOCC, generating telemetry displays locally, for monitoring on VAXStation 3100 workstations at the CDA station.

The present CDA station equipment configuration is shown in Figure 3.

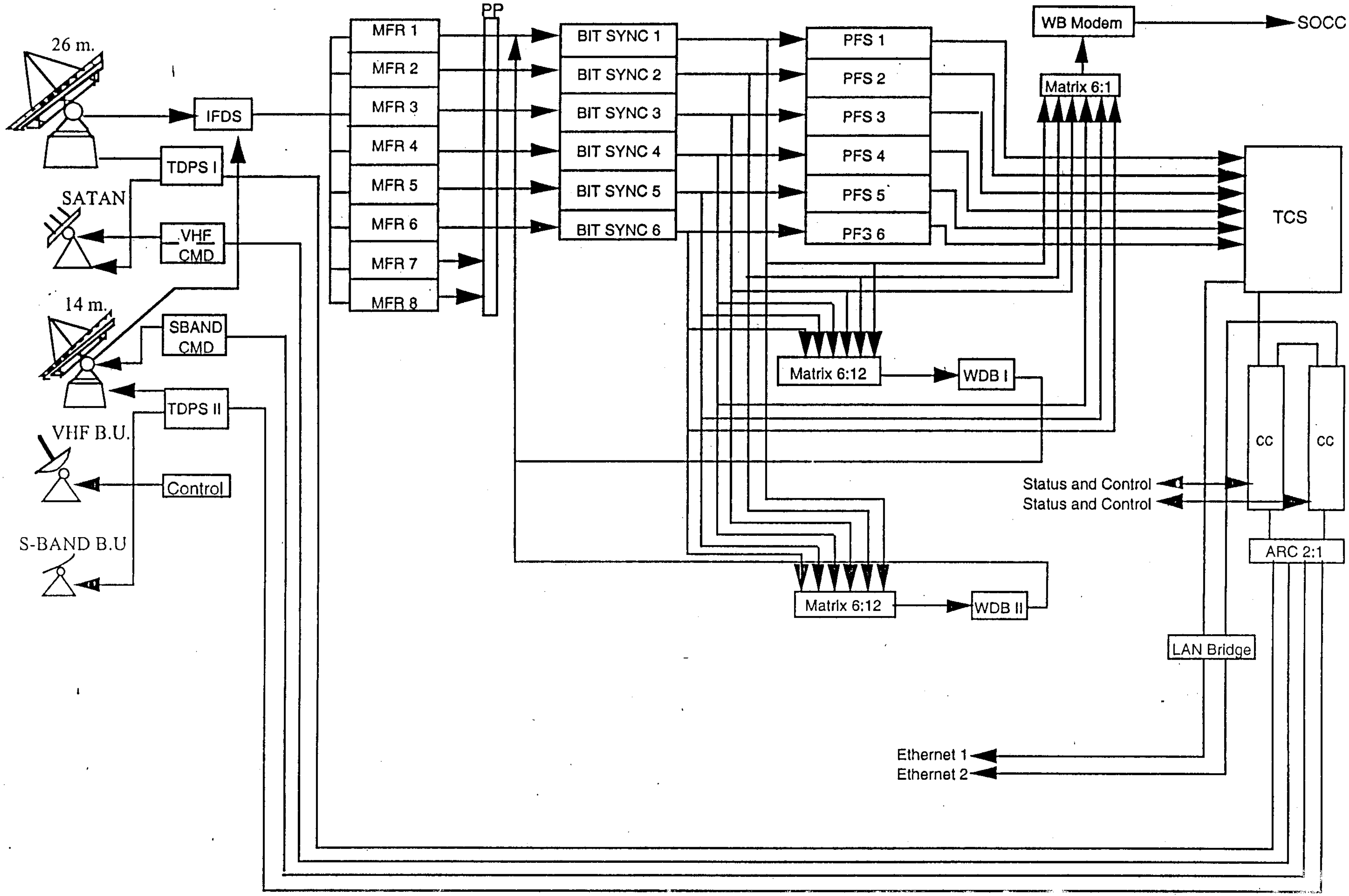

FIGURE 3: WALLOPS CDA STATION

6.0 OPERATIONS

Polar satellite operations are conducted on a 24 hours a day, seven days a week continuous basis at a ground system availability greater than 99%. System operation to configure the SOCC and CDA station for the satellite to be acquired, data collection and command activities while the satellites are within the acquisition circle of a CDA station, and the transfer of collected data to the SOCC is categorized as real-time operations. Functions performed to support realtime operations are considered non-realtime activities.

Each Telemetry and Command Subsystem (TCS) computer at the SOCC and the CDA stations is capable of supporting data collection, telemetry processing, and command generation for three satellites simultaneously. At the SOCC one TCS computer conducts real-time operations while a second is on line as a redundant backup. The third TCS, acquired as a spare for the two on line computers, is normally used to support the non-realtime activities of system operation. The single TCS computer at each CDA station is maintained continuously on line for system operations. Schedule driven, automated control of polar satellite operations conducted from the SOCC consists of three phases of operation, as follows:

Prepass Oneration: Prior to Acquisition of Signal (AOS) by a CDA station, the station Command Level Schedule executes set up commands and test procedures to establish and verify that the SOCC and CDA station are properly configured and functional for command and acquisition of data from the satellite to be acquired. During this phase antennas are prepositioned to the azimuth and elevation coordinates (as projected by the scheduling function) necessary for signal acquisition.

Station Pass Onerations: Upon receipt of a downlink signal and verification that the satellite is in the primary antenna beam, the CDA station acquires and transfers to the SOCC via a 1.33 Mbps communications satellite link, the realtime HRPT signal containing 1 km data with the 8.32 kbps low rate TIP data imbedded. During the station pass the satellite SCT activates the necessary switching to cause selected on-board digital tape recorders to play back recorded 1 km. Local Area Coverage, 4 km Global Area Coverage, and Stored TIP data collected during the orbit.

Post-pass Ooeration: Upon loss of signal (LOS) the received DTR playback data is transferred sequentially to the SOCC, thence to CEMSCS, under schedule control.

6.1 Realtime Operations

The period of realtime operations extends from the start of Prepass activities, nominally 10 minutes prior to Acquisition of Signal (AOS), through up to 13.5 minutes of Pass activities depending upon satellite elevation, and through the Post-pass phase of variable duration dependant upon the number of stored satellite DTR playback records to be transferred to the SOCC.

Current realtime operations provide for safety and health monitoring only of a second, non-conflicting (without mutual RF interference), satellite over a CDA station simultaneously with a satellite for which full data acquisition, command, and control functions are performed.

6.1.1 SOCC Realtime Operations

In normal operations, the SOCC controls all the command and data acquisition activities of the polar system by means of a daily schedule. In the SOCC a Satellite Controller monitors on a workstation color monitor, the execution and verification of each activity contained in the Stored. Command Table on board the spacecraft. He has command authority to uplink commands to the spacecraft in realtime for spacecraft subsystem control in response to any unforeseen event during the satellite pass. The Satellite Controller is responsible for initiating and monitoring the daily upload of the daily Stored Command Table which is of 30 hour duration to assure schedule overlap, and other memory loads required for satellite operation. The Satellite Controller is in voice communications with a counterpart Satellite Controller at the CDA station whose role is to monitor in the same manner, the scheduled-operations. The CDA controller has command authority only when it is relinquished by the SOCC controller, or is preempted by the CDA station in the event of a SOCC failure.

During the pass, an Aerospace Engineering Technician (AET) at the SOCC monitors the performance of the satellite subsystems. He may select from a data base of 200 display formats or, based upon the particular parameters of concern, construct a display page containing those associated parameters that best characterize a particular subsystem's status. The AET is provided the option of monitoring one, two, or four display pages simultaneously, in either alphanumeric text or graphic form. Telemetry displays have associated limits sets that cause values to be displayed in green for nominal values, in yellow for non-nominal values, and in red when a value exceeds its limits. The AET has provision to temporarily redefine limits sets for any parameter to meet his immediate needs, without effecting the controlled database values. The system performs a "state check" function to alert the AETs when the status of the satellite subsystem at AOS is different from its status at the previous LOS, accounting for the status changes scheduled to be commanded by the SCT during the back orbit.

6.1.2 CDA Station Realtime Operations

.NOAA CDA stations are staffed by maintenance personnel who serve as system operators for realtime activities. At the CDA station, realtime operations are conducted by an Antenna Operator, a Satellite Controller, and a Station Controller.

An Antenna Control Console provides an operating position for the Antenna Operator whose function includes the manual positioning of the antennas during the Prepass phase of operation to the coordinates to acquire the satellite as it ascends over the antenna's horizon profile. Antenna pointing data is provided by a Tracking Data Processing Subsystem (TDPS) associated with each tracking antenna. Upon AOS, the Antenna Operator engages the "autotrack mode" of antenna operation when the received signal strength (Automatic Gain Control AGC level) indicates the satellite signal is in the main lobe of the antenna pattern. The TDPS also provides a “program track” mode of operation, selected by the Antenna Operator, in the event of autotrack mode failure. The tracking antennas at the Wallops CDA station are committed to polar satellite operations and are also used to generate GOES tracking data when available between polar satellite passes.

The Satellite Controller at the CDA station performs the same schedule monitoring functions as the controller at the SOCC and has the same command capability when assuming command authority. His operating position is a PACS workstation with the same data selection and display capabilities as provided at the SOCC. He is in direct voice communications with the SOCC and coordinates his observations with the SOCC controller during the pass.

The Station Controller’s role is to monitor CDA station subsystem status and performance during realtime operations and to activate redundant equipment or data paths when sub-standard performance is observed. A data path is preestablished with a Multi-function Receiver (MFR) tuned to a particular frequency, a PACS Bit Synchronizer (PBS), and a PACS Frame Synchronizer (PFS) configured for a particular data rate and format. During prepass operation, the daily Command Level Schedule running on the TCS computer, through the station Communications Controller activates switching devices to assign the appropriate data paths for the satellite to be acquired. The Station Controller, by keyboard entry at his workstation operating position, can control station equipment as required during the station pass.

During the pass, the Command Level Schedule controls the switching associated with the 14 channel tape recorder Wideband Data Buffers (WDB) to direct the received down link data streams to designated tracks of the recorder. The Command Level Schedule also controls the record/playback mode of the WDBs and their start-stop times of operation. It also controls the sequential routing of data from each recorder track to the wideband modem for post-pass transfer of data to the SOCC over the 1.33 Mhz satellite channel.

6.2 Non-realtime Operations

Activities essential to the successful conduct of polar satellite operations which are conducted off-line, independent of realtime command and data acquisition functions, are categorized as non-realtime operations. Included are the functions of Scheduling, Navigation, and Spacecraft Engineering.

6.2.1 Scheduling

Scheduling is the activity to generate computer files for the daily Stored Command Table for each spacecraft and the corresponding Command Level Schedule for each CDA station. The scheduling process also generates listing and reports to support NOAA operations as well as polar data users worldwide.

Schedules are based upon the ephemeris of each-satellite which defines the satellite location against time. The ephemerides of NOAA polar orbiters are generated by the NOAA Central Computing Facility based upon orbital elements received daily, to create a User Ephemeris File (UEF) for each satellite. The UEF, with an Orbit Number File and a Greenwich Hour Angle file for each satellite, is input twice weekly to the PACS Ephemeris Subsystem non-realtime software. There it is used to generate for a user specified time interval, the satellite ground track, day/night terminator crossing times, and spacecraft illumination. The Ephemeris Subsystem generates Equator Crossing, Automatic Picture Transmission (APT) Channel Reset, Station Contacts, and ERBE/SBUV command times, interface data files to be used by the Master Scheduler process of the scheduling software. It provides hard copy reports of these data to support polar operations. Based upon the ephemeris, it also generates the Inter-Range Vectors forwarded to the CDA stations' TDPS for generation of antenna pointing data. The Ephemeris Subsystem also produces a TIROS Bulletin United States messages 1,2,3, and 4 that are transmitted to realtime users via Weather-Facsimile (WEFAX) through the GOES satellite, and to users worldwide via the WMO global teletype network.

The Ephemeris Subsystem provides the products which are the basis for creating Master Schedule Event Level Schedules, the SOCC and CDA Command Level Schedules, and the satellite Stored Command Table loads. The Master Schedule is nominally run weekly, covering a ten day period. The Master Schedule Event Level Schedules are lists of time-ordered events which specify all required SOCC and CDA station activities and satellite commands. The SOCC and CDA station Command Level Schedules are a series of PACS directives which execute at the SOCC and CDA stations to control spacecraft commanding and data collection. The satellite Stored Command Table loads consist of stored commands uplinked daily to the satellite to execute according to a spacecraft clock to control the scheduled collection, recording, playback, and transmission of sensor data.

A Schedule Generation process, run daily, covering a 30 hour period, expands the Master Schedule Events Files into PACS directives to be executed at the SOCC and CDA stations, and Stored Command Table loads to be executed on the spacecraft. A Schedule Validation Process checks the Event Level Schedules for errors and inconsistencies. A Stored Command Load Validation process checks Stored Command Load Files for errors and inconsistencies, and for discrepancy in the overlap period between consecutive days' Stored Command Tables.
As a result of slightly different orbital parameters, more than one orbiting polar satellite periodically appear within the acquisition circle of a CDA station at the same time. A Conflicts Identification process provides an interface between the Ephemeris Ground Track process and the Master Scheduler Subsystem to provide a list of all potential station acquisitions for all NOAA polar satellites. The process identifies conflicts which occur when more than one satellite is in view of the CDA station 26 meter antenna acquisition circle at any given time. (A software upgrade is planned to define conflict as an instance in which more than one spacecraft are in the antenna pattern of either the 26 meter or 12/14 meter antennas). The Master Scheduler verifies satellite-CDA contact information and resolves conflicts to specify which satellite to acquire

according to scheduling criteria, and produces an Interrogation Schedule for each CDA station. It assigns data collection tasks, Elapsed Time Clock reset, and APT channel selection for each orbit, and ground station tasks for each satellite pass. Data collection tasks include on-board tape recorder management and their schedule for Local Area Coverage (LAC) data recording and playback. For all selected satellite passes, the Master Scheduler configures the SOCC and CDA stations for Prepass, Pass, and Post-pass Events, schedules downlink data transmissions and command uplinks, and CDA to SOCC data transfers. The Master Scheduler incorporates frequently used repetitive command sequences of spacecraft commands through use of Scheduler Procedures ("Procs") and Macro Commands.

The Master Scheduler Subsystem is run in two parts; the Conflict Resolution and LAC Automation process, and the Master Scheduler process. The Conflict Resolution process designates which spacecraft to acquire in cases of conflict for the use of the CDA station tracking antenna. The LAC Automation process schedules the record, playback, and ingest transfer of GAC, LAC, STIP, and SAIP data. The Master Scheduler process:

- determines if a Stored Command Table is to be uplinked for each pass
- generates the Command Access Period (CAP) open and close events, if requested, two minutes before AOS and two minutes after LOS
- schedules recording of data and DTR assignments from the previous CDA contact through AOS for the current contact
- schedules events for DTR playback and WDB operation for transfer of DTR data to the SOCC
- identifies AOS, First Command Time (FCT), First Receive Time (FRT), Last Receive Time (LRT), Last Command Time (LCT), and LOS
- generates events to turn S-band transmitters on before and off after DTR playback
- generates events to turn on the WDB prior to FRT anh off after LRT

6.2.2 **Navigation**

The Navigation function of polar satellite operations is to support the preparation and validation of a weekly ephemeris update to the stored on-board ephemeris table used by the ADACS attitude control subsystem. A non-realtime software process, Geodat Parameter, produces a 32 word ephemeris data table for uplink to the satellite by parameterizing a ground-based spacecraft User Epliemeris File. A Geodat Ephemeris process of the Navigation function simulates the onboard processing of the ephemeris table to validate the Geodat load for quality control.

An additional capability of the Navigation function is the analysis of ADACS gyro performance. The Gyro Drift process supports computation of gyro drift models from telemetry history data and maintains a cumulative file of gyro drift biases for long term monitoring of gyro performance. An associated Attitude Monitor process provides ground based recomputation of spacecraft roll/pitch attitude error based on Earth Sensor Assembly data, combined with recomputation of yaw attitude error. Yaw attitude error is based on yaw gyro rate integration together with sun sensor yaw updates.

6.2.3 Spacecraft Engineering

The Spacecraft Engineering function is responsible for the health and safety of the polar satellites. It performs the analysis of spacecraft performance over the life of the satellite, does performance anomaly analysis and resolution, and generates the command procedures to maintain spacecraft subsystems at specified levels of performance. Spacecraft Engineering maintains an interface with spacecraft subsystem engineers and is responsible for maintaining the command and telemetry data bases unique to each spacecraft. Spacecraft Engineering also performs simulator operation to support test and training activities of polar satellite system operations.

In support of the Spacecraft Engineering, the PACS provides a History capability to create and maintain on-line history files of raw telemetry data for tip to 4 spacecraft, at the SOCC and CDA stations. The History Archive process consolidates telemetry data from all sources to archive in daily files of up to 2700 major frames indexed chronologically. History files are maintained for five days at the SOCC and one day at the CDA stations.

The PACS provides at the SOCC a Trends process to create and maintain on-line trends archive files of statistics of spacecraft subsystem performance. Trends archive files contain the minimum, maximum, and mean (M^3) value for up to 1200 hundred telemetry or pseudo telemetry points (a derived data value generated by a combination of actual telemetry sensor values) for each orbit of each spacecraft. Trend archive files are maintained on-line at the SOCC for a one year period and are accessible by Spacecraft Engineering and other SOCC operations personnel through keyboard entry at any SOCC Operator/Engineer workstation.

History and Trends archive files are created and updated automatically, without operator intervention, while the data is being received during a pass or postpass period.

7.0 **DATA FLOW**

This section presents a brief description of the flow of data from their sources, through components of the spacecraft and ground system, to their eventual destination. An overall representation of satellite and ground system major components which collect, route and process polar satellite mission data is shown in Figure 4: “Polar Data System”.

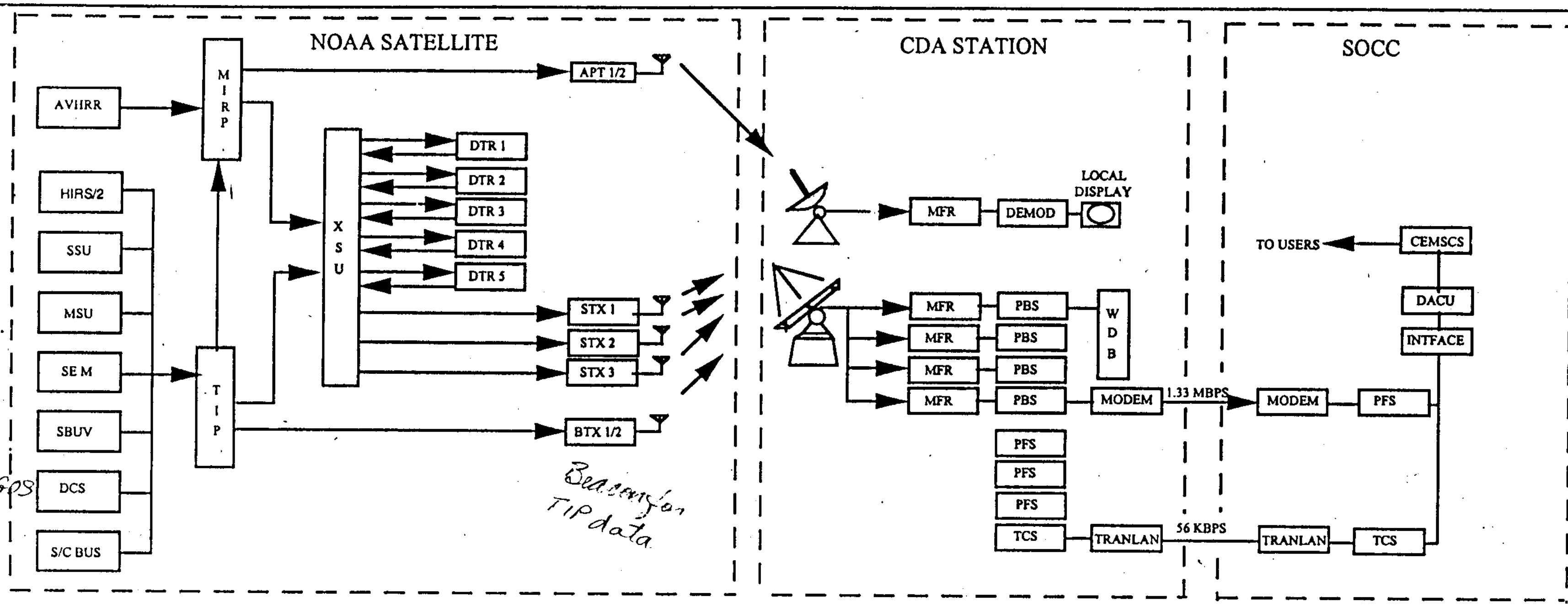

FIGURE 4: POLAR DATA SYSTEM

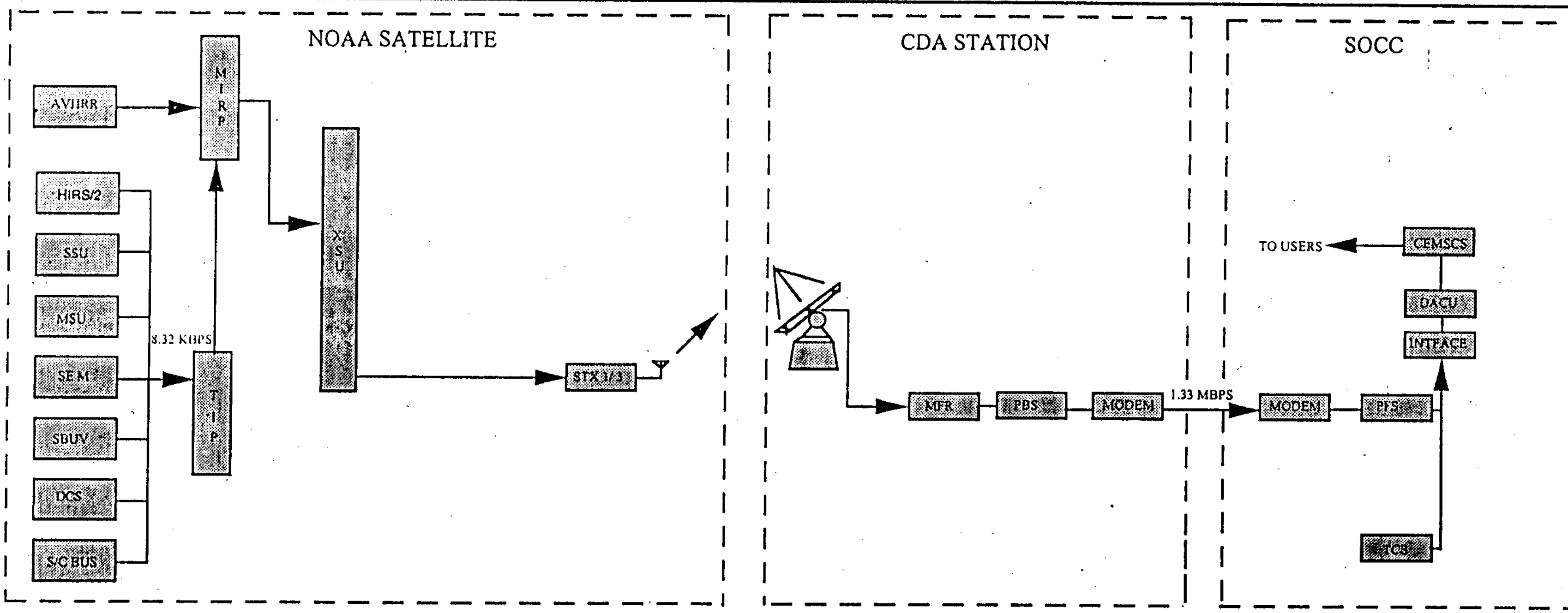

FIGURE 4A: HRPT DATA FLOW

7.1 Data Types

Each mission instrument generates three types of data, as follows:

- Mission Data Mission data consists of the digitized sensor/detector output of the instrument, including calibration data, which the instrument generates. With respect to the spacecraft DHS, these are designated "Digital A" data. Dig. A of Table 1 contains the data rate in bits per second (bps) for each instrument.

- Instrument Status Data Each instrument generates single bit discrete indicators of the status of the instrument configuration, (e.g. Off/On, Enable/Disable) designated "Digital B" data. The number of Dig. B data points, by instrument, is shown in Table 1.

- Analog Telemetrv Each instrument generates analog telemetry values for conditicns of instrument operation such as temperatures, voltages, currents, etc. These measurements are taken for housekeeping purposes to maintain the health and safety of the instruments. The number of analog data points, by instrument, is shown in Table 1.

	AVHRR	HIRS/2	SSU	MSU	EEM	SBW	DCS	SARP	AMSU
DIG A*	199680	2880	480	320	160	420	1200**	2400	7040
DIGB	14	14	4	8	10	22	10	10	48
ANALOG	12	16	12	10	14	17	10	9	TBD

* Bits per second (bps)
** Upgraded to 2560 for NOAA K-N

Table 1: Instrument Data Output

7.2 Data Formats

Spacecraft of the NOAA H-J series generate two basic data formats; the HRPT format and the TIP format. Spacecraft of the NOAA K-N' series introduce the Advanced Microwave Sounding Unit (AMSU) and an additional AMSU Information Processor (AIP) format. These basic formats are packaged by on-board electronics to produce downlink transmissions of data at the various data rates described.

7.2.1 TIP Data

All payload instruments with the exception of the AVHRR, for Series NOAA H-J spacecraft, are low data rate devices. All data from all instruments except the AVHRR, and all telemetry from monitoring points of thespacecraft subsystems are formatted by the satellite DHS redundant TIROS Information Processors (TIP) into a 8.32 kbps data stream. Instrument electronics perform analog to digital conversion and condition instrument data for direct-input to the TIP, based upon synchronization signals provided by the TIP processor. The 8.32 TIP data stream format provides a 0.1 second minor frame containing 103 8-bit words, including synchronization bits, spacecraft identification, command verification, TIP status, major frame number, and parity check bits. The TIP major frame contains 320 minor frames for the 32 second major frame rate.

7.2.2 AVHRR Data

The five channel AVHRR instrument Dig. A mission data is output to the DHS Manipulated Information Rate Processor (MIRP) sequentially as ten bit parallel digital words, along with a line synchronization signal. Analog and Dig. B housekeeping data are sampled by and routed directly to the TIP processor. The output of the MIRP is the HRPT signal, a 0.166 sec. minor frame containing a synchronizing signal, header, auxiliary sync signal, 127 spare words,-520 TIP words, and 1024 Dig A mission data words, for a total of 110,900 bits per minor frame. The HRPT major frame consists of 3 minor frames every 0.5 secs., or 6 times 110900 bits a second, for a 665.4 kbps output rate

7.2.3 AMSU Data

Data from the AMSU instrument will be collected, formatted and combined with existing HRPT, GAC, and LAC data streams, with analog and Dig. B housekeeping data inserted into spare words in the TIP housekeeping telemetry. Mission data produced by the AMSU will be combined with the TIP data to form a new 16.64 kbps AMSU Information Processor (AIP) data stream. The AIP data will consists of 103 8 bit words appended to the front of the 103 8 bit word TIP minor frame to form the 206 word AIP minor frame format, output at the TIP 32 second major frame rate.

7.3 Data Paths

The flow of data from spacecraft instruments through components of the spacecraft and ground system is as follows:

7.3.1 AVHRR Data Flow

The AVHRR data are processed by the MIRP to produce four separate output formats:

- High Resolution Picture Transmission (HRPT)
- Global Area Coverage (GAC)
- Local Area Coverage (LAC)
- Automatic Picture Transmission (APT)

7.3.1.1 HRPT Data

The MIRP combines AVHRR data with TIP data to produce a 665.4 kbps output consisting of six minor frames of 110,900 ten bit data words a second. The HRPT data is routed through the spacecraft XSU to either the high (HSB) or low (LSB) S-band transmitter for continuous broadcast. At a CDA station, the received signal is down converted to an Intermediate Frequency (IF) at the antenna for input through preestablished data paths to an MFR tuned to the resultant IF frequency. The MFR demodulates the signal to the original 665.4 kbps baseband signal for input to a PBS bit synchronizer which recovers timing and outputs data and clock. These signals are input to the CDA station wideband data modem for satellite transmission to the SOCC, as shown on Figure 4A: “HRPT Data Flow”.

At the SOCC the HRPT data is input to a PFS frame synchronizer which synchronizes on the input signal, does a data quality check, strips the TIP data, and outputs the frame synchronized AVHRR high rate data to the. CEMSCS interface and to a SOCC TCS processor. At CEMCSC the data is preprocessed into Level 1 b data for distribution to end users.

At the SOCC the high rate PFS input to the TCS is examined for data quality information and a performance report generated. The low rate stripped TIP data output of the PFS is input to the TCS where it is decommutated, limit checked, formatted for display, and distributed via the Ethernet to the SOCC work stations. This ‘processing is an operational alternative to processing of TIP data received, over the 56 kbps narrowband link from the CDA station, described below.

7.3.1.2 GAC Data

HRPT data at the nominal I km. resolution of the AVHRR can be acquired only in realtime, when the satellite is within the acquisition range of a ground station antenna. In order to achieve ‘meteorological imaging coverage on a global basis it is necessary to reduce the data rate and thereby the resolution to **4 km.,** to conform to the on-board DTR capacity limitation. This data rate reduction is accomplished by the MIRP by selecting every third scan line and by averaging the content of four of five samples of each scan line to produce a 66.54 bps data output. This processing results in the capability of recording global data for the entire 102 minute orbital period.

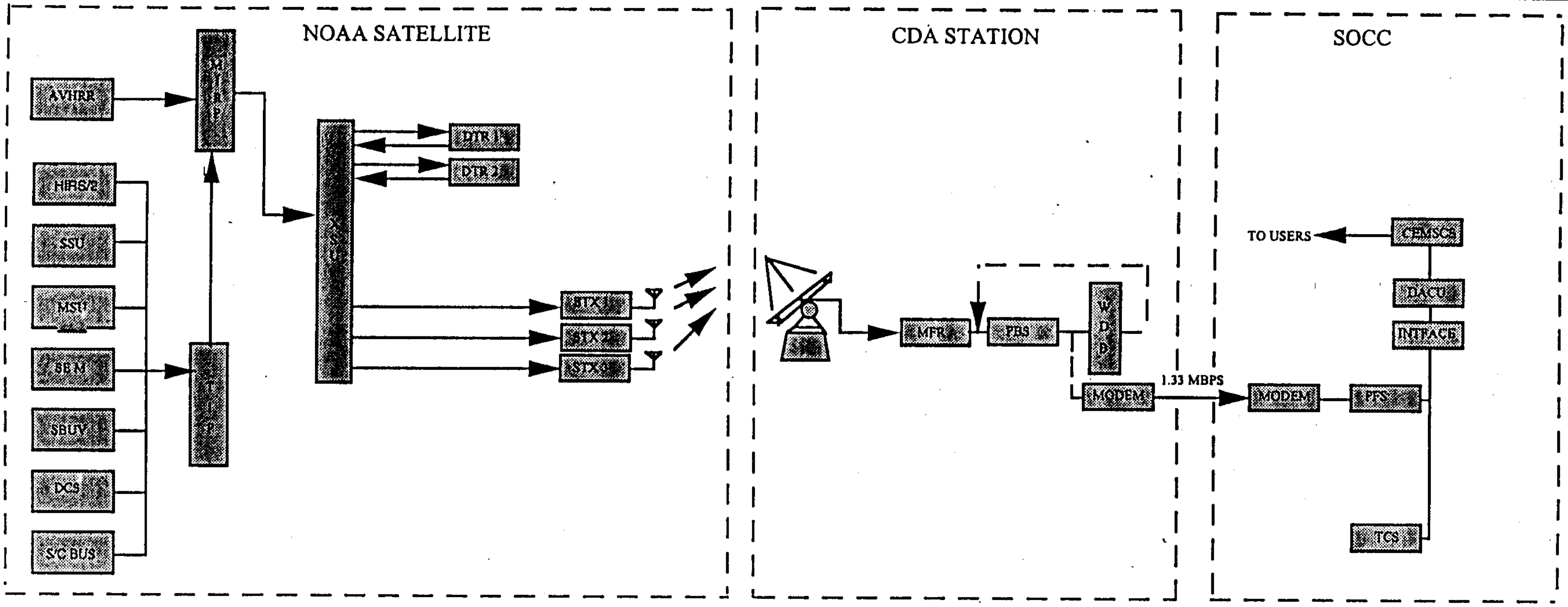

FIGURE 4B: POLAR PLAYBACK DATA

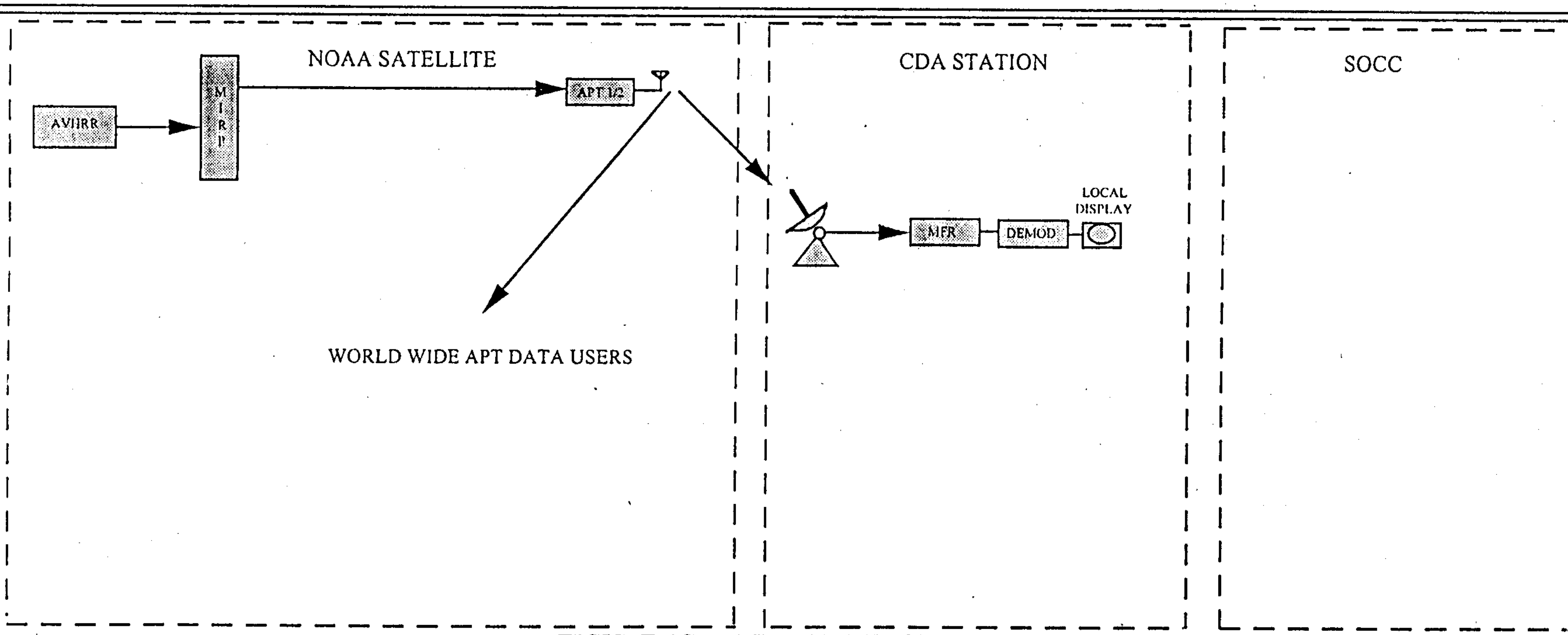

FIGURE 4C: APT DATA FLOW

As illustrated in Figure 4B: "Polar Playback Data", data from the AVHRR and TIP data are input to the MIRP where the reduced resolution data is routed through the XSU for recording on one of two tape transports of the five DTRs. In the playback mode, under control of the satellite SCT, the recorded data is played back in reverse, with most recent data first. This playback data is routed by the XSU to one of two available S-band transmitters for transmission to a CDA station at 2.6616 Mbps, in 2.8 minutes.

At the CDA station the received signal is routed through an MFR and PBS and input to one of three tracks of the CDA station wideband data buffer (WDB) for recording, most recent data first. During the post-pass period of operation, GAC data which has highest priority, is played back at one half the recorded rate, and transferred to the SOCC over the 1.3308 Mbps satellite channel. The GAC data is played back without rewinding the WDB tape so that the data is reordered with earliest data output first. The GAC data is routed, through computer controlled'switching, as input to its assigned PBS, thence to the wideband data modem for transmission to the SOCC, as indicated by the dotted lines of Figure 4B.

At the SOCC the received GAC data is from the satellite channel through the wideband modem, through a PFS to the PACS/CEMSCS interface, through the DACU for preprocessing into Level 1 b products for distribution to end users. The 1 b processing appends 'earth location and calibration coefficients to the GAC data but does not earth locate nor calibrate the raw data. The output of the PFS is also routed to the SOCC TCS for data quality measurements which are compared with the measurements taken at the CDA station as a measure of satellite link performance.

7.3.1.3 LAC Data

LAC data handling is identical to that described for GAC except that it is an up to 11.5 minute sub-set of the MIRP HRPT 665.4 kbps 1 km. resolution data, limited by the DTR recording capacity. Areas of coverage are requested by using agencies and are incorporated into the polar system schedule so that satellite DTRs are enabled, and ground system equipment is activated for receipt and transfer of LAC data to SOCC and CEMSCS, by automated schedule control.

7.3.1.4 APT Data

APT data is generated by the MIRP from two AVHRR channels, selectable under SCT control. During daylight hours the visible and one IR channel are used, switching to two IR channels as the satellite crosses the day/night terminator into darkness. APT data is routed from the MIRP through the XSU to one of two VHF transmitters for continuous broadcast as a 2400 baud subcarrier. . Figure 4C: "APT Data Flow" illustrates the spacecraft configuration and also contains an optional CDA station configuration used to monitor APT data quality.

7.3.1.5 AIP Data

As shown on Figure 4D: “AMSU Configuration” the AMSU instrument will introduce the AMSU Information processor (AIP) to process the AMSU data and generate the 16.64 kbps data stream described in para. 7.2.3, above. The AIP processor will be interposed between the TIP processor and the MIRP which will replace the imbedded TIP data in the HRPT, GAC, and LAC with the new AIP data stream. introduction of. the **AIP** data will not alter the format of the MIRP output as the AIP data will occupy one of three data blocks which currently contain the same TIP data block of 520 words which is repeated in each major frame. As shown on Figure 4D, with AMSU the direct path from the TIP to the VHF transmitters will continue to provide the 8.32 kbps TIP Beacon broadcast.

7.3.1.6 Stored TIP/AMSU Data

The Series H-J spacecraft currently have provision for storing global TIP data on the satellite DTR recorders in the Stored TIP (STIP) format, ‘played back as shown on Figure 4B and downlinked at 332.7 kbps. The NOAA K-N’ seiies will provide for recording and playback of Stored AIP (SAIP) data at the 332.7 kbs downlink data rate.

7.3.2 TIP Data Flow

All payload instruments of the NOAA H-J series except the AVHRR, are clocked by and output data to the TIP processor to generate the 8.32 kbps TIP data stream. The TIP output is routed to directly to two VHF Beacon Transmitters (BTX) and to the MIRP. The TIP Beacon frequency is selected by commanding the transmitters off or on depending upon the satellite orbit (AM or PM). TIP Beacon is broadcast continuously and is the source of all polar satellite meteorological data, except imagery, to data users world wide.

The TIP beacon is received-by the VHF elements of CDA station multi-frequency tracking antenna, upconverted and routed to an MFR tuned to the appropriate IF frequency. The TIP baseband signal is routed from the MFR through a PBS to a PFS to the CDA station TCS processor. The TCS processor, in addition to decommutating the TIP data for local display routes the data via the Ethernet to the Translan III bridge to the 56 kbps communications circuit to the SOCC. At the SOCC the TIP data is routed from the receiving Translan III via the Ethernet to a SOCC TCS processor for health and safety-monitoring of the satellite. This data path is an alternative source of realtime TIP data to that which can be extracted from the HRPT data stream as described in para. 7.3.1 .1, above. The data path for TIP Beacon data is shown on Figure 4C: “TIP Data Flow”.

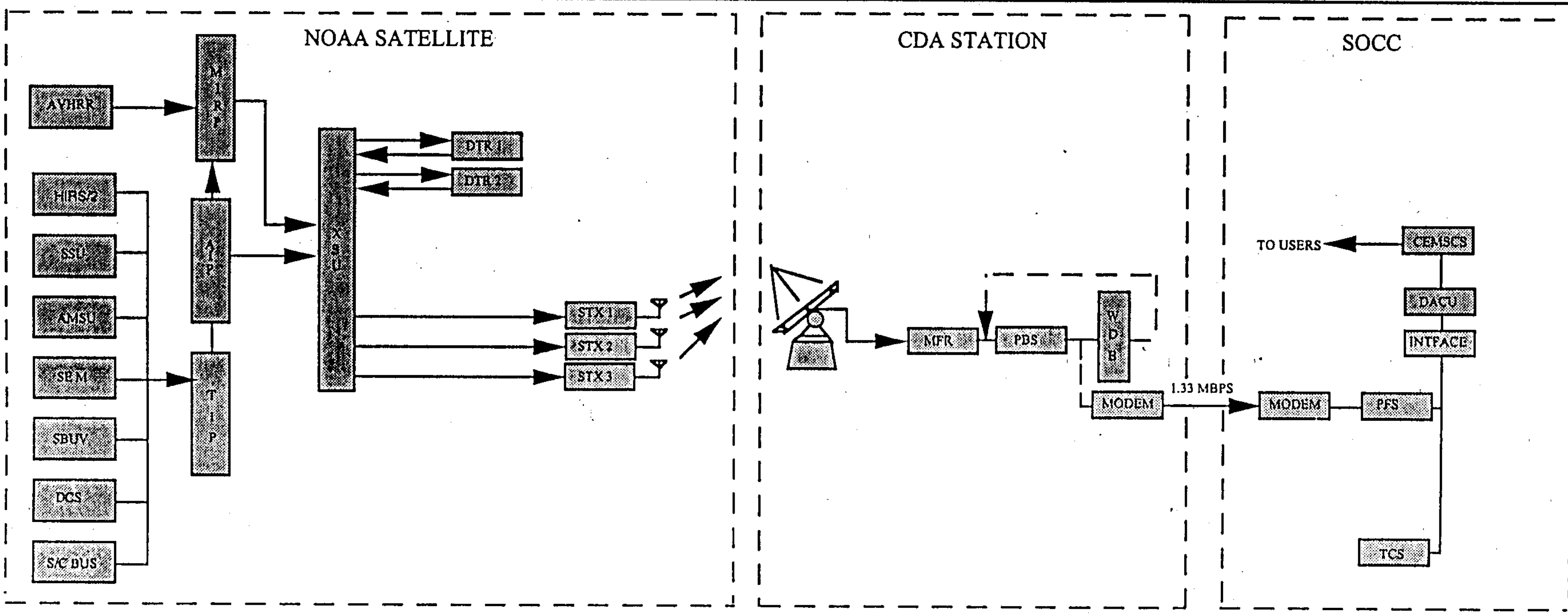

FIGURE 4D: AMSU CONFIGURATION

List of Acronyms

ADACS	Attitude Determination and Control Subsystem
AET	Aerospace Engineering Technician
AGS	Ascent Guidance System
AKM	Apogee Kick Motor
AMSU	Advanced Microwave Sounding Unit
AOS	Acquisition of Signal
APT	Automatic Picture Transmission
ATN	Advanced TIROS-N
AVHRR	Advanced Very High Resolution Radiometer
CAP	Command Access Period
C&CS	Command and Control Subsystem
CDA	Command and Data Acquisition
CEMSCS	Central Environmental Satellite Computer Center
CPU	Central Processing Unit
DCS	Data Collection System
DoC	Department of Commerce
DTR	Digital Tape Recorder
ERBE	Earth Radiation Budget Experiment
FRT	First Receive Time
GAC	Global Area Coverage
GSTDN	Goddard Space Tracking and Data Network
HIRS/2	High Resolution Infrared Sounded:!
IR	Infrared
LAC	Local Area Coverage
LCT	Last Command Time
LOS	Loss of Signal
MIRP	Manipulated Information Rate Processor
MSU	Microwave Sounding Unit
NESDIS	National Environmental Satellite Data Information System
NOAA	National Oceanic and Atmospheric Administration
PACS	Polar Acquisition and Control Subsystem
PBS	PACS Bit Synchronizer
PFS	PACS Frame Synchronizer
RAIDS	Remote Magnetospheric and Ionospheric Detection System
SAIP	Stored AMSU Information Processor
SAR	Search and Rescue
SBUV	Solar Backscatter Ultra Violet
SCT	Stored Command Table

SEM	Space Environmental Monitor
SGLS	Space Ground Link System
SOCC	Satellite Operations Control Center
s s u	Stratospheric Sounding Unit
STIP	Stored TIROS Information Processor
TDPS	Tracking Data Processing Subsystem
TIP	TIROS Information Processor
TIROS	Television Infrared Observational Satellite
TOVS	'TIROS Operational Vertical Sounder
TT&C	Tracking, Telemetry, & Command
UEF	User Ephemeris File
WDB	Wideband Data Buffer
WMO	World Meteorological Organization
XSU	Cross Strap Unit